Globalization of Next-generation Core Network Control Technology

Takumi Ohba†, Tomonori Takeda, Kaori Shimizu, Ichiro Inoue, and Shigeo Urushidani

Abstract

This article introduces globalization trends in the architecture and protocols for controlling the next-generation core network, which will efficiently accommodate various kinds of services and rapidly growing traffic using both IP (Internet protocol) control technology and photonic technology. It also describes some activities of NTT Network Service Systems Laboratories in this area as examples: a multilayer service network architecture, L1VPN (layer-1 virtual private network), and GMPLS (generalized multiprotocol label switching) interoperability testing.

1. Need for globalization

As the next-generation core network utilizes both IP (Internet protocol) control technology and photonic technology, a wide range of consensus and cooperation among carriers and vendors is essential to enable the use of advanced equipment of both types from the world's markets. The architecture and protocols must be standardized to assure global reachability, which is one of the most significant merits of the Internet. At the same time, interoperability verification through various channels, such as forums, academic organizations, and interoperability test events, is also important to assure the connectivity of real equipment that embodies the standards in a multivendor environment. Thus, globalization (i.e., standardization and interoperability verification on the worldwide scale) will play an important role in achieving the next-generation core network and providing service systems economically in the near future (**Fig. 1**).

2. Standardization

NTT Network Service Systems Laboratories is active in standardizing the architecture and protocols for the next-generation core network. The most relevant standards bodies in this area are ITU-T (International Telecommunication Union, Telecommunication Standardization Sector), the IETF (Internet Engineering Task Force), and the OIF (Optical Internetworking Forum). The following subsections explain the standardization activities for the multilayer service network architecture and L1VPN (layer-1 virtual private network). The former is one example of architecture standardization, which is most significant as the first step in globalization. The latter is expected to be one of the new services that the next-generation core network will provide.

† NTT Network Service Systems Laboratories
Musashino-shi, 180-8585 Japan
E-mail: ohba.takumi@lab.ntt.co.jp

2.1 Multilayer service network architecture

ITU-T Study Group 13 (SG13), which is actively studying networks and architectures, is studying the requirements and architecture of the next-generation network (NGN), which makes use of various broadband and QoS-enabled transport technologies and supports generalized mobility, which will allow consistent and ubiquitous provision of services to users (QoS: quality of service). The multilayer service network architecture is included in draft Recommendation Y.2011 [1] as part of the NGN architecture based on NTT's proposals. Consent for Y.2011 to become a new recommendation was given in June 2004.

Y.2011 shows the multilayer network scenario in

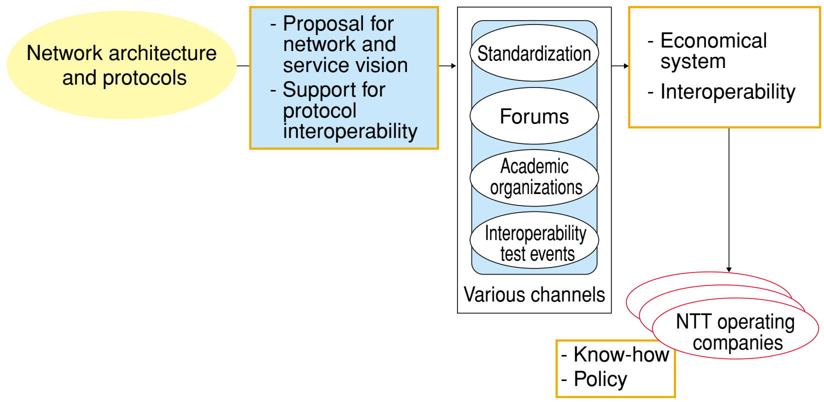

Fig. 1. Globalization in Optical+IP technology.

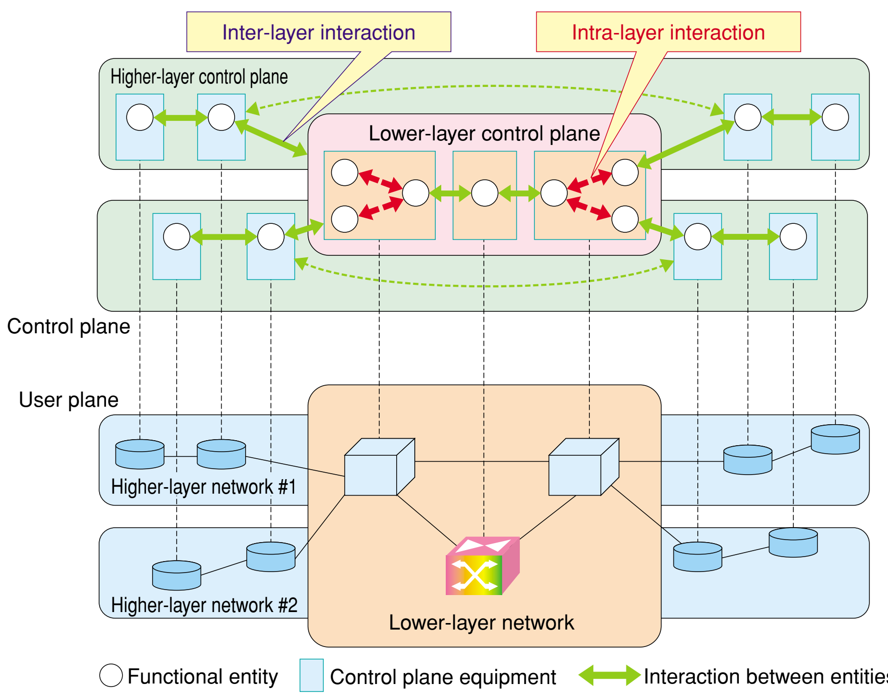

Fig. 2. Multilayer network scenario specified in NGN.

the multilayer service network architecture (**Fig. 2**). It shows that two functions are required to achieve the characteristics of the multilayer service network architecture. They will support cooperation between layered networks and accommodate various service networks.

(1) Inter-layer interaction

A coordination function between higher and lower layers is needed to manage and control multilayer information simultaneously.

(2) Intra-layer interaction

A coordination function between functional entities in the lower layer (one being common for multiple higher layers and the other being for an individual higher layer) is needed to accommodate multiple higher-layer networks, or service networks, with the single lower-layer network.

It is also necessary to study protocols in standardization bodies, such as IETF or ITU-T, to enable equipment to be implemented. Architecture standardization that includes NTT's proposals aligns the starting points of various activities for studying protocols for the multilayer service network architecture.

2.2 Layer-1 virtual private network

L1VPN is a new service being created by combining IP control and photonic technologies (**Fig. 3**). It provides super broadband dynamic networking services to large-scale users, such as Internet service providers (ISPs), by treating a carrier's optical network as multiple virtual optical networks. L1VPN also provides network control customization, such as routing within a carrier's network or selection of protection levels, by opening the network control to users by means of generalized multiprotocol label switching (GMPLS) protocols.

SG13, which is responsible for studying VPNs in ITU-T, gave consent for Y.1312 [2] as the carrier's service requirements for L1VPN and for Y.1313 [3] as the service and network architecture of L1VPN in July 2003 and February 2004, respectively. NTT acted as the editor of these recommendations and greatly contributed to L1VPN standardization. As a carrier, NTT widely promoted the need for L1VPN service in the marketplace and accelerated technical studies for achieving L1VPN.

In addition, protocol enhancements, such as exchanging VPN-IDs, member information, and topology information, need to be standardized. As the first step, NTT has proposed the framework of L1VPN to IETF based on discussions in SG13. The next steps involve studying the applicability of the existing GMPLS-related protocols and proposing and discussing the detailed specifications required for L1VPN.

3. Interoperability verification

Constructing a network with the architecture and services mentioned above will require a wide range of advanced equipment based on both IP and optical technologies. As this equipment will be provided by multiple vendors, it is becoming more and more important to verify interoperability of real network equipment. Furthermore, in the development stage of standardization, as in the case of the next-generation core network, feedback from interoperability verification to standardization activities and cooperation between them will accelerate progress in related technologies.

UNH-IOL (University of New Hampshire Interoperability Laboratory), ISOCORE, and OIF in the USA and PIL (Photonic Internet Lab.) [4] in Japan are major bodies performing interoperability verification related to the Optical+IP field. UNH-IOL and ISOCORE were founded as interoperability sites to verify protocols, such as ATM and MPLS. Universities in the USA act as neutral organizations to test the interoperability of multiple vendors' equipment that implement multiple carriers' requirements. The protocols discussed in the standardization bodies, such as IETF and OIF, are tested in the interoperability sites and then modified and implemented as practical protocols. PIL aims to promote standard technology

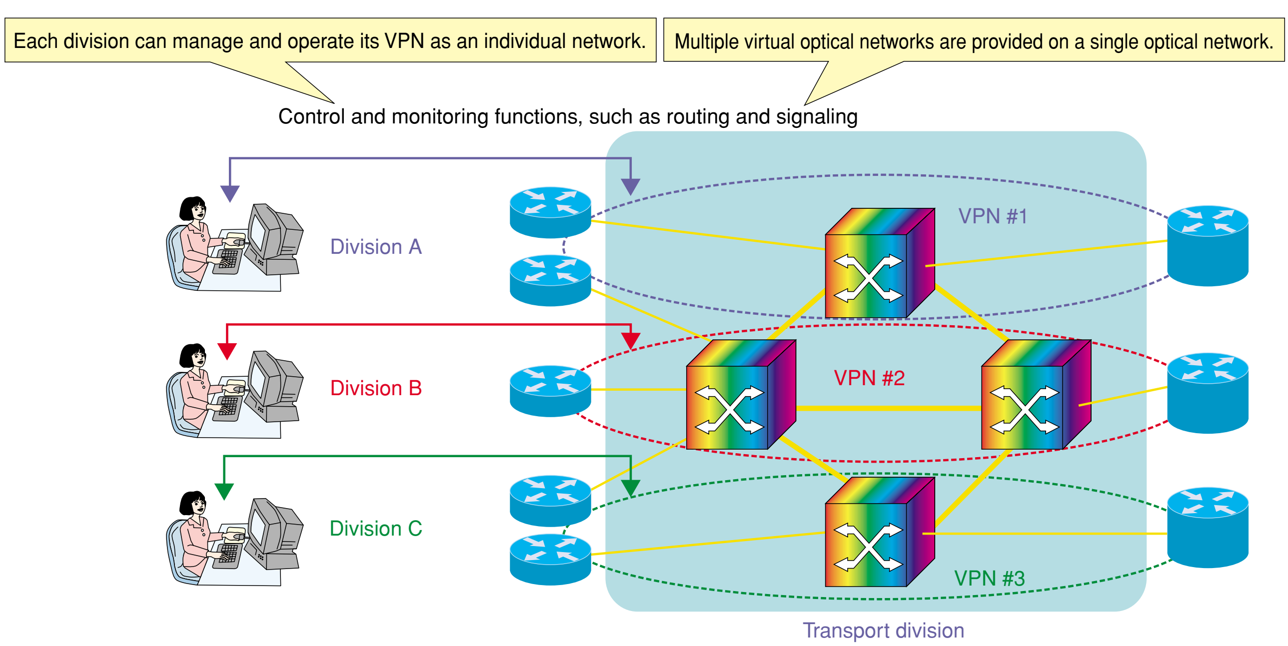

Fig. 3. Services of a layer-1 VPN.

from Japan and interoperability in the photonic field. It is supported by the Japanese government.

Many interoperability test events of basic protocols for the next-generation core network, such as GMPLS, have been performed through public demonstrations and the results have been published openly [5], [6]. It is getting more important to promote interoperability verification at the level of providing real network services.

NTT Network Service Systems Laboratories is proposing test items necessary for the provision of carrier-grade services to UNH-IOL and ISOCORE and is promoting interoperability test events; thus, the Labs., as a carrier, is determining the order of priority of the functions to be achieved in terms of the test items. In addition, the verification of the interoperability demonstrates the achieved levels of related technologies.

3.1 GMPLS interoperability testing in UNH-IOL

The first OSRM (optical signaling, routing and management) test event was held from January 12th to 16th 2004 in UNH-IOL. The participants were one router vendor, three OXC (optical cross-connect) vendors, two tester vendors, and NTT Network Service Systems Laboratories as a service provider.

NTT Network Service Systems Laboratories led the development of advanced test items from the viewpoint of providing carrier-grade services. Based on NTT's proposals, test items for stable network operations, such as operation in the event of a control channel failure and re-routing after a link failure (**Fig. 4**), as well as basic path setup and release, were performed and the interoperability of equipment from multiple vendors was checked [7].

Re-routing after a link failure is an essential function for providing network services and there are various ways of doing it. In this event, the simplest method, which requires minimum implementation but can bypass the failed link quickly, was verified. In the tested method, once a link failure occurs, the best route is re-calculated and the path is re-established. Test steps for the link failure re-routing are as follows:

1. Edge node #1 (EN1) requests a fiber-level path between EN1 and EN2.
   - Confirm that the best route, EN1→CN3→CN5→EN2, was selected and the path established on that route.
   - Confirm that route EN1→CN1→CN2→EN2 was not selected because CN1 and CN2 have a different switching capability (lambda level) from the request (fiber level), even though it is a three-hop route and has the same cost as the selected route.
   - Confirm that route EN1→CN3→CN4→CN5→EN2 was not selected because it has one more hop than the selected route even though the

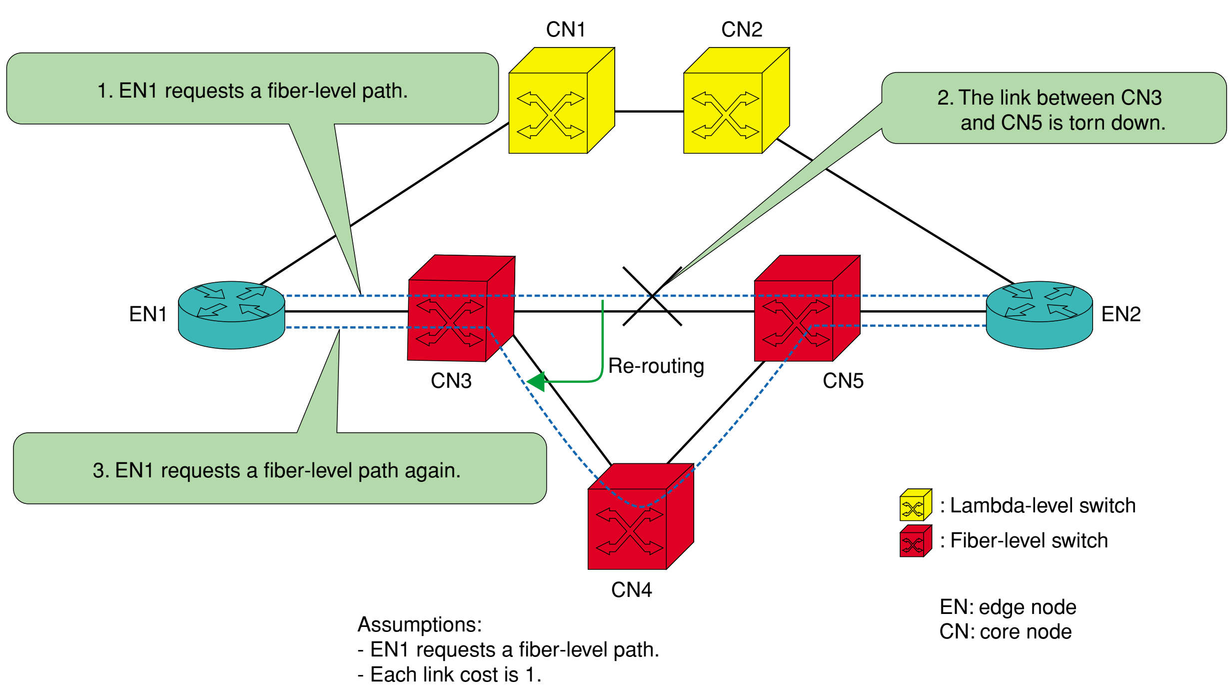

Fig. 4. Re-routing after a link failure.

switching capability matches the request.
2. Tear down the link between CN3 and CN5.
3. EN1 requests a fiber level path again.
   - Confirm that the current best route, EN1→CN3→CN4→CN5→EN2, was selected and the path established on that route, based on the route re-calculation without the link between CN3 and CN5.
   - Confirm that route EN1→CN1→CN2→EN2 was not selected because CN1 and CN2 have a different switching capability (lambda level) from the request (fiber level) even though it is a three-hop route and has a lower cost than the selected route.

Some issues in the current specifications were clarified through the interoperability testing, and they were proposed to key persons in the GMPLS study in IETF. They were then discussed in the mailing list of the IETF CCAMP WG (Common Control And Management Plane Working Group), which is responsible for GMPLS specifications, and the related specifications were upgraded.

In future, NTT Network Service Systems Laboratories will contribute to the progress of the Optical+IP field by performing interoperability testing using more advanced test items or service-related items, such as L1VPN, and by publicizing the results of events through public demonstrations.

References

[1] ITU-T Recommendation Y.2011, “General principles and general reference model for NGNs,” 2004.
[2] ITU-T Recommendation Y.1312, “Layer 1 Virtual Private Network Generic requirements and architecture elements,” 2003.
[3] ITU-T Recommendation Y.1313, “Layer 1 Virtual Private Network service and network architectures,” 2004.
[4] http://www.pilab.org/
[5] http://isocore.com/PR/june2004.htm
[6] http://www.oiforum.com/public/pressroom/Demo04-June9.pdf
[7] http://www.iol.unh.edu/consortiums/osrm/

Takumi Ohba
Senior Research Engineer, Network System Innovation Project, NTT Network Service Systems Laboratories.
He received the M.S. degree in physics from the University of Tokyo, Tokyo in 1993. He joined NTT the same year and has been studying ATM signaling. Since April 2004, he has been promoting globalization of the next-generation network. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

Tomonori Takeda
Engineer, Network System Innovation Project, NTT Network Service Systems Laboratories.
He received the M.E. degree from Waseda University, Tokyo in 2001. He joined NTT the same year and has been engaged in research on the next-generation network architecture, IP optical network architecture and related protocols. He is a member of IEICE and IEEE.

Kaori Shimizu
Engineer, Network System Innovation Project, NTT Network Service Systems Laboratories.
She received the B.S. degree from the University of Electro-Communications, Chofu, Tokyo in1995. She joined NTT the same year. Currently, she is studying IP optical network architecture and protocols. She is a member of IEICE.

Ichiro Inoue
Senior Research Engineer, Supervisor, Network System Innovation Project, NTT Network Service Systems Laboratories.
He received the M.E. degree in electrical engineering from the University of Tokyo, Tokyo in 1990. He joined NTT the same year. Since then, his research interests have included telecommunication protocols such as IP and ATM. He has been active in standardization such as ISO/ISC (as a national committee member), ITU-T, and IETF. He was a visiting researcher at Columbia University, USA in 1995.

Shigeo Urushidani
Senior Manager and Research Group Leader, NTT Network Service Systems Laboratories.
He received the B.E. degree in electrical engineering and M.E. degree in electronic engineering from Kobe University, Kobe, Hyogo in 1983 and 1985, respectively. He received the Ph.D. degree in electronic engineering from the University of Tokyo, Tokyo in 2002. In 1985, he joined NTT, where he engaged in R&D of ATM switching systems and optical switching systems. In 1992, he moved to NTT Network Engineering Headquarters and began working on strategic planning and construction of intelligent, broadband, public communication networks. He is currently involved in R&D of next-generation IP optical networks at NTT Network Service Systems Laboratories. He is also a Visiting Professor at the National Institute of Informatics (NII). He received the excellent paper award (1988) and the young engineering award (1990) from IEICE. He is a member of IEEE.